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THE DESIGN AND USE OF A BUOYANT MISSILE FOR THE
RECOVERY OF ANGLED ARROW PROJECTILE COMPONENTS

28 JULY 1953



U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

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THE DESIGN AND USE OF A BUOYANT MISSILE FOR THE
RECOVERY OF ANGLED ARROW PROJECTILE COMPONENTS

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ABSTRACT: This report summarizes the development of a reliable method for recovering AAP component parts after they are gun fired at approximately 4,000 ft/sec. This method requires the use of a buoyant missile fired over water and then recovered. A number of experimental sondes, rocket motor sub-assemblies, and fuzes have been successfully recovered to date.

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This report is compiled for the information of those persons and activities interested in the subject or the application of the technique described. The test program was carried out and this report prepared under the authorization of task NOL-Re38-614-1-53. This report is distributed for information only.

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By direction

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THE DESIGN AND USE OF A BUOYANT MISSILE FOR THE
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INTRODUCTION

1. The development of ordnance components is generally hampered by the lack of rigorous laboratory simulation of the loads imposed on the components when the missile is fired from a gun. This is particularly true for electronic components, since their mechanical strength is difficult to determine and they are often subject to damage by shock or impact loading. Certain methods, such as the airgun and drop tests, provide a limited simulation of the load conditions. At an early stage of the Angled Arrow Projectile Program, however, more accurate simulation was desired so that a program to provide it was instituted.

2. Since firing from the appropriate gun and then recovering the parts provides a realistic approach, efforts were directed toward the development of a simple, reliable recovery system. Several systems were considered. It was decided that the use of a buoyant missile, fired over water and recovered by boat, was most practicable. This technique also made it possible to monitor the RF signal from the sonde in flight.

3. Since the AAP is a sub-caliber projectile having a body diameter of 4.5 inches and is fired from an 8"/55 gun, it is evident that the same gun could be used for the buoyant missile. The maximum diameter of the components to be carried is approximately 3.5 inches and the difference between this and the bore diameter provides sufficient wall thickness for the missile. The required over-water firing site is suitably provided by the Potomac River firing range at Naval Proving Ground, Dahlgren, Virginia.

4. The initial design work was carried out in early 1952 and two experimental missiles were constructed and fired. These are designated as Rounds 1 and 2 in Table 1. The first round, fired at slightly reduced charge, was recovered intact, but only a part of the second round, fired at full charge, was recovered. The firing of these rounds served to illustrate the feasibility of the technique and the required design revisions. The design of these two rounds is covered in TN-2129, and a photograph of the recovered Round 1 is included in NAVORD Report 2612.

Missile Design

5. Following the demonstration of the feasibility of the technique, certain basic design parameters were established. The vehicle was to be constructed primarily to carry a standard AAP sonde package, having a weight of 7.0 pounds. The round was to be fired from an 8.25"/55 smooth bore gun. In order to simulate the actual ballistics, the total round was to weigh approximately 105 pounds and the muzzle velocity to be

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4,000 ft/sec. With this weight and muzzle velocity, the maximum design acceleration would therefore be 15,000 g.

6. The complete round as designed consists of two parts, the body and the slug, and is shown in Figure 1. The body is the buoyant part which encloses the component being tested. The slug brings the round to the required weight and provides obturation in the gun. The slug and the body separate in flight shortly after emerging from the gun.

7. The main part of the body is made of $1\frac{1}{2}$ inch thick sugar pine planks glued up with the grain parallel to the longitudinal axis. This wood is used since it is a readily available material with a high strength to weight ratio. The wood is dried to 10-12% moisture content, then finished and assembled using Penacolite Adhesive G-1260. The front cover is made of maple, also held in place by glue and screws. Maple is used because the front cover acts as a bore riding surface and must withstand abrasion. The rear plate and sonde support sleeve are aluminum. The plate is primed with Cycleweld C-3 and held in place with Armstrong A-1 adhesive and screws.

8. Figure 1 shows the first missiles constructed to this design. Although the two early missiles (Rounds 1 and 2) incorporated a fiberglass wrapping around the outside diameter, this was eliminated on Rounds 491 and 492. Examination of the photographic data showed that these two rounds broke up after leaving the gun. It was thought that the exposed end grain on the rear surface of the body was the most vulnerable part and should be covered with fiberglass. Since there was still some question as to the necessity of covering the sides of the body, Round 496 was prepared with only the rear surface covered and round 495 was made up completely wrapped. Upon firing, Round 496 broke up, but Round 495 was recovered intact, thus indicating the necessity of completely wrapping the body. All succeeding rounds were treated in this manner with the addition of a red dye in the wrapper as an aid in spotting the floating missile. The technique of wrapping the missiles in fiberglass is described in NAVORD Report 2795.

9. The general design characteristics of the first models are as follows:

Weight of Sonde -	7 pounds
Total Weight of Body -	21 pounds
Positive Buoyancy -	10 pounds without water in cavity
-	8 pounds with water in cavity
Total Weight of Round -	105 pounds
Stress level in wood at rear of body -	3,500 psi
Handbook permissible stress in compression parallel to grain -	4,770 psi

10. In the first design the front cover was provided with a sloping surface. This surface was intended to cause the round to quickly tumble in flight and thereby aid in the separation of the body and the slug. On Round 553 this surface was replaced by a flat cover. Since the arrangement operated satisfactorily, the slope was eliminated on all following rounds.

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11. In the course of the firing tests, other minor modifications have been incorporated to improve the construction. The last two missiles, Rounds 576 and 577, had the front covers bolted but not glued to provide an easy and fast method for assembling and disassembling the missiles. The present design, as modified, is shown in Figure 2. In addition, special alterations have been made to certain rounds to accommodate components other than the sonde for which the missile was designed. Figure 4 shows a standard missile that was modified to accommodate a complete AAP rocket motor. This is Round 569 in Table 1 and carried the heaviest component fired. Other changes had been planned for future rounds such as the replacement of the wooden front cover with a fiberglass or aluminum cover to overcome cover warpage and the use of weldwood glue in place of the penacolite adhesive to facilitate the fabrication of the missile.

Firing Results

12. A summary showing all rounds fired to date, including those modified, is shown in Table 1. It may be seen that, since the start of the fiberglass wrapping, only one round (565) has failed structurally and not been recovered. This particular round carried tracers with the slug drilled through, permitting the burning gas to ignite the tracers. Apparently this gas impinging on the base of the body caused the failure of the round. Two other rounds (572 and 573) were lost when the water became rough and the retrieving boat could not locate them upon reaching the area where they were last seen.

13. Figure 3 is a photograph of the recovered and disassembled Round 557. The missile has not been damaged and is suitable for future firing. Round 509 was refired three more times (as Rounds 553, 555 and 567) before it was damaged during disassembly. Some rounds have been refired several times and others are suitable for refiring after making minor repairs.

CONCLUSIONS

14. By the use of a buoyant missile fired over the water, a reliable recovery technique has been developed. The buoyant missile, as designed, will accommodate the AAP sonde and certain other components of the same general size and weight. This technique provides an accurate simulation of the actual loads imposed on the component, since the firing tests are conducted under the same ballistic conditions. With this technique it has been possible to test-fire experimental components, record generated sonde signals, recover fired components and examine them in detail for structural failure and other malfunctions. The technique has permitted the rapid evaluation of certain new designs, thereby expediting development work, especially in the electronic field, in the AAP Program.

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Appendix A

<u>Drawing Title</u>	<u>Drawing Number</u>
Buoyant Missile	
Pinocchio II Assembly - - - - -	BuOrd Sketch 356575
Body - - - - -	BuOrd Sketch 353651
Plate - - - - -	BuOrd Sketch 356576
Deflector Plate - - - - -	BuOrd Sketch 356603
Deflector Plate - - - - -	BuOrd Sketch 357648
Sleeve Support - - - - -	BuOrd Sketch 373519
Sleeve - - - - -	BuOrd Sketch 353653
Glass Cloth Wrapper - - - - -	BuOrd Sketch 422420

Missile Modification for Rocket Motor

Modified Pinocchio - - - - -	BuOrd Drawing 1370697
Body - - - - -	BuOrd Drawing 1246624
Support Plate - - - - -	BuOrd Drawing 1246623
Plate - - - - -	BuOrd Drawing 1246616
Lid - - - - -	BuOrd Drawing 1246617
Sleeve - - - - -	BuOrd Drawing 1246615
Washer - - - - -	BuOrd Drawing 1190624
Gasket - - - - -	BuOrd Drawing 1190623
Tie Rod - - - - -	BuOrd Drawing 1190622

Table 1

FLIGHT TEST DATA

Rnd. No.	Shoot No.	Date Fired	Component Tested	Component Weight Lbs	Fluted Weight Lbs	Total Weight Lbs	Q.E.	Maximum Breech Pressure Tons Cu	Missile Recovered
1	53/52	3/21/52	Sonde osc. 677	6.5			10 ⁰	7.6	Yes
2	"	"	Sonde osc. 172	6.5			"	13.2	A section without sonde
491	58/52	5/22/52	Sonde osc. E-1	7.0	21.1	104.0	10 ⁰	13.1	No
492	"	5/23/52	Sonde osc. E-2	7.0	21.3	104.3	"	12.8	No
495	73/52	6/20/52	Sonde osc. 727	7.1	22.9	105.8	"	11.9	Yes
496	"	"	Sonde osc. 739	7.2	20.9	103.8	"	12.2	No
500	10/53	8/13/52	Sonde osc. E23	-	21.6	104.5	"	12.8	Yes
501	"	"	Sonde osc. E25	-	21.5	104.5	"	12.4	Yes
508	21/53	11/5/52	Sonde osc. 789	-	21.8	104.8	"	11.1	Yes
509	"	"	Sonde osc. 790	-	21.9	104.8	"	11.2	Yes
553	27/53	12/18/52	38 Prim. / Ampl.	-	20.5	103.5	"	6.1	Yes
554	31/53	1/30/53	Sonde osc. E47	7.2	22.3	105.4	"	7.7	Yes
555	"	"	Sonde osc. 794	7.3	22.2	105.3	"	7.8	Yes
556	33/53	3/31/53	FV unit	1.8	18.6	101.0	15 ⁰	3.1	Yes
557	"	"	"	2.7	17.3	99.6	"	12.0	Yes
558	34/53	3/31/53	Rocket Safety Units	-	21.8	104.2	"	12.2	Yes
565	35/53	"	4 Mod tracers	1.6	15.1	90.6	"	11.4	No
566	42/53	4/8/53	Sonde osc. 806	7.1	23.7	106.8	"	12.3	Yes
567	"	"	Sonde osc. E68	7.0	21.6	104.6	"	12.1	Yes
568	40/53	4/15/53	Telem. Sonde	6.7	22.8	106.0	30 ⁰	13.4	Yes
569	44/53	4/23/53	Rocket Motor	10.0	24.5	107.6	"	12.8	Yes
570	50/53	4/23/53	Sonde osc. 835	-	24.0	107.1	"	13.4	Yes
571	"	"	Sonde osc. 836	-	23.0	106.0	"	12.5	Yes
572	52/53	5/1/53	Sonde / Det.	6.9	24.6	107.7	"	N.T.	Lost
573	"	"	"	6.9	23.9	107.0	"	"	Lost
574	47/53	5/22/53	FV unit	1.8	18.5	101.6	"	12.4	Yes
575	"	"	Telem. Sonde	-	22.5	102.3	"	12.3	Yes
576	60/53	6/11/53	Sonde osc. 346	6.4	22.7	105.8	"	-	Yes
577	"	"	Sonde osc. 347	6.3	21.9	105.0	"	-	Yes

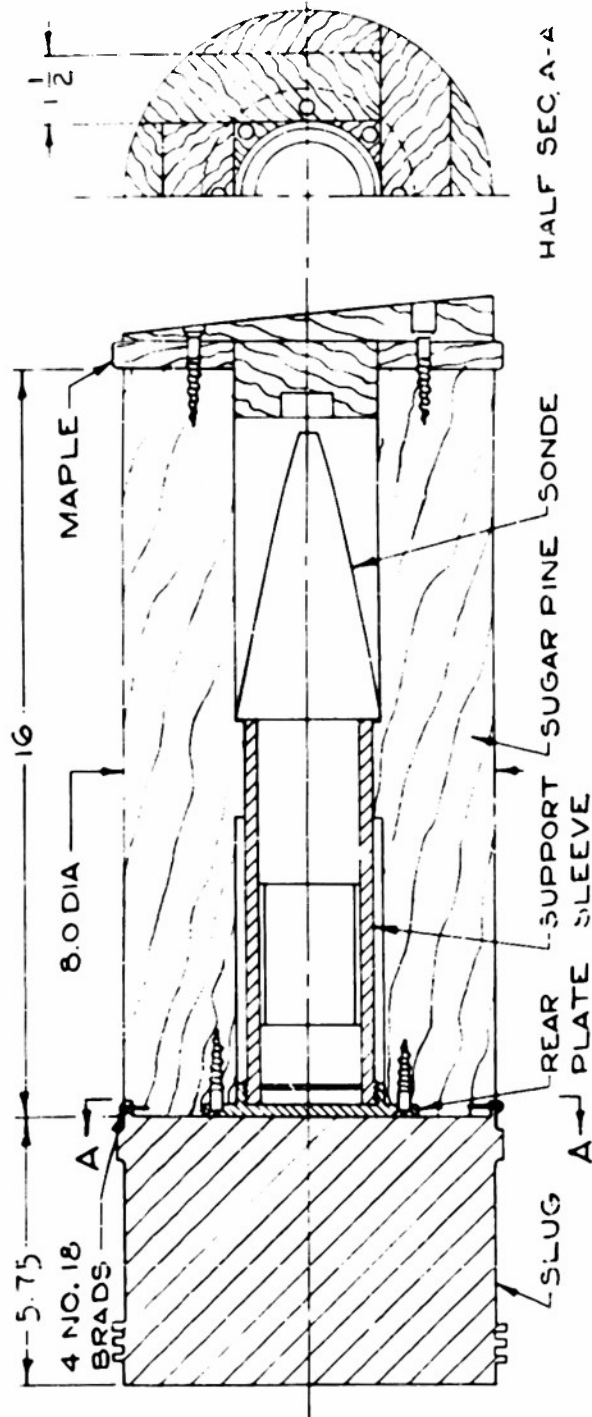


FIG. 1 BUOYANT MISSILE - EARLY

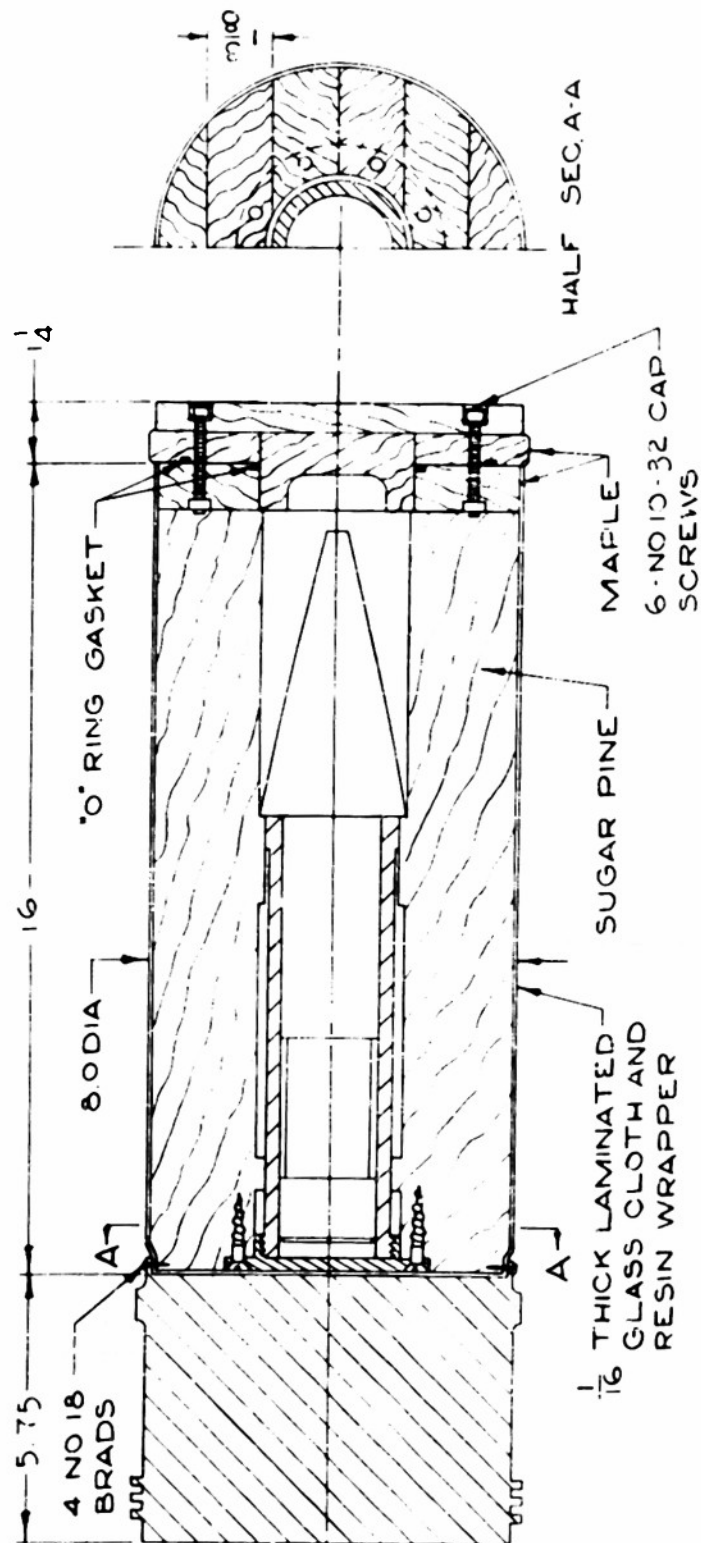


FIG. 2 BUOYANT MISSILE - PRESENT

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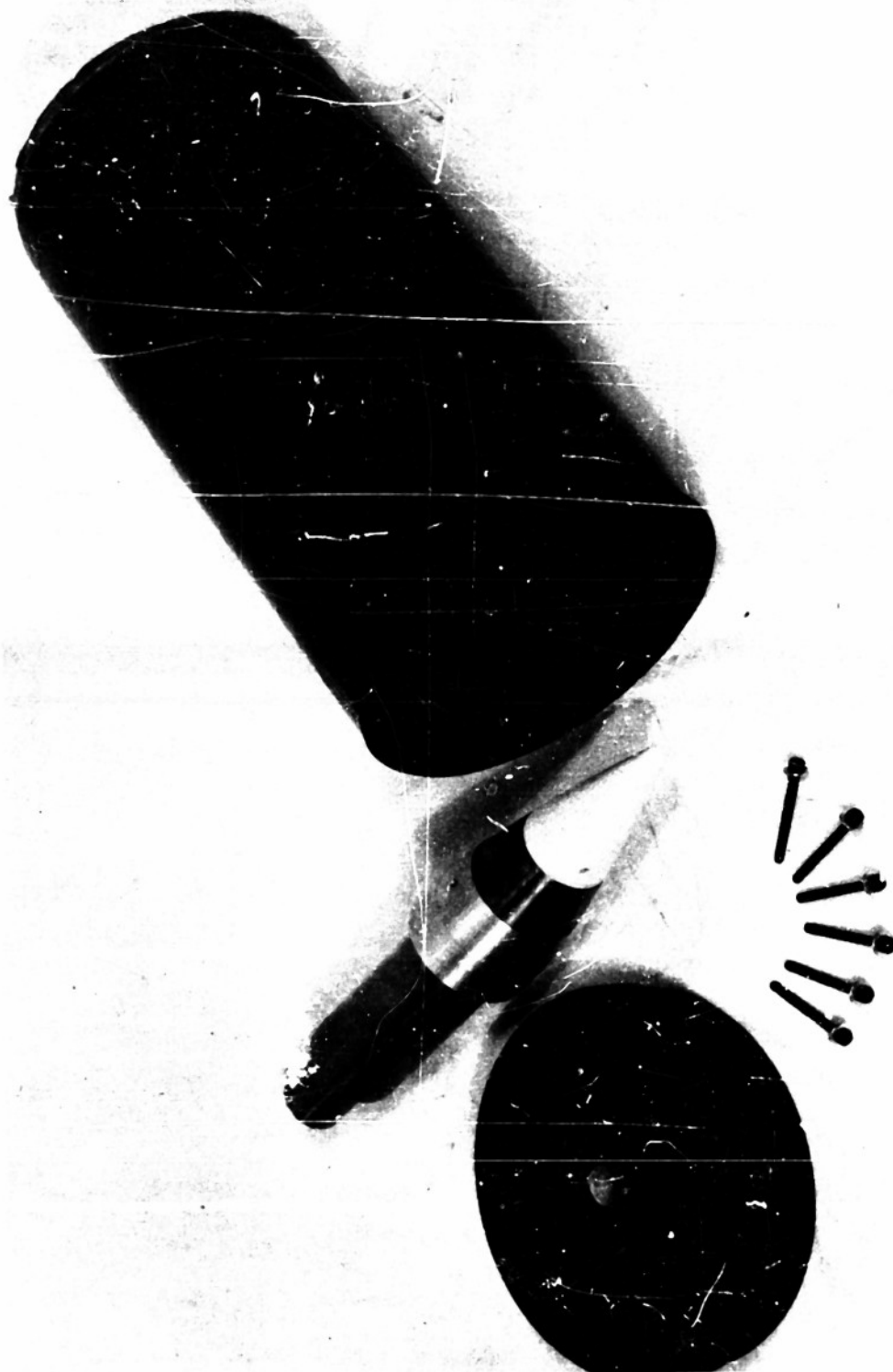


FIG. 3 RECOVERED BUOYANT MISSILE

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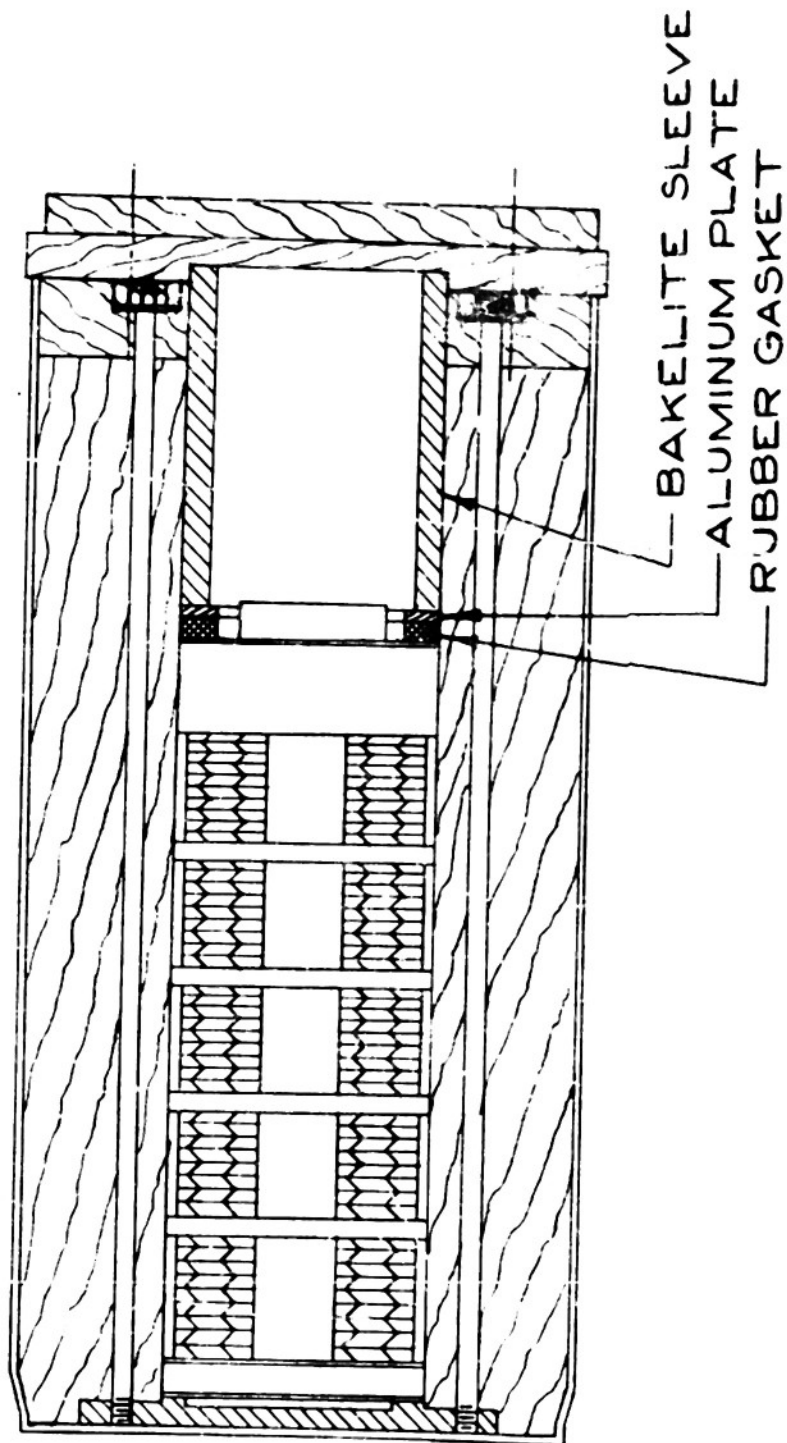


FIG. 4 BUOYANT MISSILE - MOD. FOR ROCKET MOTOR